Expert System for Diagnosing Disease Symptoms of Rice Pests Using the Dempster Shafer Algorithm and Fuzzy Tsukamoto Algorithm

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***Abstract*— Agriculture is the largest sector in almost every developing country economy. This sector produces food for most of the population in the country. Some Indonesian people work as farmers who have an important role to ensure the availability of basic ingredients, namely rice from rice. However, the limited number of experts, namely Field Agricultural Extension Officers (PPL) results in limited counseling that will be obtained by farmers, because to overcome all the problems faced by farmers, it is constrained by time and the number of farmers who have problems with their crops. In this case, farmers find it difficult to deal with problems of pests and diseases that attack rice, therefore a tool or an expert application is needed that can help farmers to diagnose pests and diseases of rice in order to provide solutions to overcome them. In connection with that, this study aims to develop an application design of an expert system for diagnosing rice pests using the Fuzzy Tsukamoto algorithm which is a method for classifying objects based on the most similar data, and adding the Dempster Shafer algorithm as a comparison of the methods used to obtain data. maximum result validation. By using the Fuzzy Tsukamoto Algorithm, the author classifies similar objects, in this case the symptoms that often occur during the rice harvest season, then compares them with the Dempster Shafter Algorithm to obtain validation of diseases that occur in rice plants based on the classification of symptoms that have been mapped. . Furthermore, the system will provide the best decision to provide advice related to diseases experienced by rice plants so that farmers can immediately resolve them.**

Keywords*— *Expert System, Expert System Application, Diagnosis of Rice Pest Disease, Fuzzy Tsukamoto Algorithm, Demspter Shafter Algorithm.

***Abstrak*— Pertanian merupakan sektor paling besar hampir di setiap ekonomi negara berkembang. Sektor ini menghasilkan bahan pangan bagi sebagian besar penduduk di negaranya. Sebagian masyarakat Indonesia berprofesi sebagai petani yang memiliki peranan penting untuk terjamin tersedianya bahan pokok yaitu beras yang berasal dari padi. Namun Terbatasnya jumlah pakar yaitu Penyuluh Pertanian Lapangan (PPL) mengakibatkan terbatasnya penyuluhan yang akan diperoleh oleh petani, karena untuk mengatasi semua persoalan yang dihadapi petani terkendala oleh waktu dan banyaknya petani yang mempunyai masalah dengan tanamannya. Dalam hal ini petani kesulitan untuk menghadapi masalah-masalah hama dan penyakit yang menyerang padi, oleh karena itu sangat dibutuhkan alat bantu atau suatu aplikasi pakar yang dapat membantu petani untuk mendiagnosis hama dan penyakit padi guna memberikan solusi penanggulangan. Sehubungan dengan itu, penelitian ini bertujuan untuk melakukan pengembangan desain Aplikasi Sistem Pakar Diagnosa Penyakit Hama Tanaman Padi dengan Algoritma *Fuzzy Tsukamoto* yang merupakan sebuah metode untuk melakukan klasifikasi terhadap objek berdasarkan data yang paling mirip, serta menambahkan Algoritma *Dempster Shafer* sebagai Perbandingan metode yang digunakan untuk mendapatkan validasi hasil yang lebih maksimal. Dengan Menggunakan *Algoritma Fuzzy Tsukamoto* ini, penulis mengklasifikasikan objek yang sejenis, dalam hal ini yaitu gejala-gejala yang sering terjadi pada musim panen padi, kemudian membandingannya dengan Algoritma *Dempster Shafter* untuk mendapatkan validasi atas penyakit yang terjadi pada tanaman padi berdasarkan klasifikasi gejala yang telah dipetakan. Selanjutnya sistem akan memberikan keputusan terbaik untuk memberikan saran terkait penyakit yang dialami oleh tanaman padi agar segera diselesaikan oleh petani.**

***Kata kunci*— Sistem Pakar, Aplikasi Sistem Pakar, Diagnosa Penyakit Hama Tanaman Padi, Algoritma *Fuzzy Tsukamoto*, Algoritma *Demspter Shafter*.**

I. INTRODUCTION

Basically, the agricultural sector is one of the most important sectors in the economy of a country, because it plays an important role in running the economy in meeting the food needs of a country. Especially in Indonesia, the agricultural sector is an important sector where most of the Indonesian population depends on the results of agriculture.

One of the basic or primary needs of the Indonesian people is rice, therefore the government needs to always maintain a stable level of rice production. In addition to providing food for the community, the agricultural sector is a supplier of raw materials for the industrial sector and a source of foreign exchange earners. Increased production of rice farming is needed to meet the food needs of the Indonesian people.

Based on information from the Department of Food Crops and Horticulture of West Java Province, in an effort to stabilize rice production, the Regional Government always

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strives to reduce the failure rate of rice crop yields, because it will greatly affect the regional economy. However, in the current era of modernization, there are still many people who do not know and utilize a facility optimally, this is due to the lack of knowledge and information obtained.

The lack of provision on agricultural land management to farmers has resulted in a lack of information about more effective technology for managing agricultural land, but it is also possible that some other farmers have started to enter the realm of modern management. To take advantage of technology during a pandemic like this, the Regional Government under the auspices of the West Java Food Crops and Horticulture Service has a program that can support farmers in the development and management of agricultural land to stabilize rice production, namely the millennial farmer program.

Millennial farmers are a program to foster entrepreneurship in the West Java agricultural sector, change the face of agriculture to be fresh so that the millennial generation is interested in becoming farmers by utilizing digital technology, creating advanced, independent, and modern agriculture, reducing the problem of the availability of agricultural labor in West Java. Millennial farmers are expected to be able to adapt in the field of technology and information so that the role of millennial farmers will be the initiators in the future.

The obstacles faced by millennial farmers now are not just how to increase rice yields, but how to improve the quality of the rice plant, one way is regarding early handling of diseases and pests in rice by applying or utilizing current technological developments. That way, the limited number of rice plant experts is no longer an obstacle for millennial farmers who have problems with their crops. Therefore, in this case, a tool or an expert application system is needed that can help millennial farmers in diagnosing pests and diseases in rice plants in order to provide solutions to overcome the problems that occur.

In previous research, the application of an expert system on symptom identification to determine pests and diseases on rice plants only used one algorithm or one method that was implemented. For example, in the research conducted by Resti Hutami et al in 2017 and Pranoto Agus et al in 2011, the two studies only used one algorithm or method, namely fuzzy Tsukamoto as a method that was implemented for diagnosis. Then there is a study conducted by Christian Yonathan Sillueta, et al in 2018 and Mustakim et al in 2016, both studies were conducted using the Dempster Shafer algorithm or method applied to their system, to diagnose diseases or disorders in the research conducted.

Yager (2008) said that The Dempster Shafer method is a method that acquires the trust value of experts based on their knowledge, to produce a precise, fast and accurate diagnosis. Another theory presented by Kohlas and Monney (2015), the Dempster-Shafer method is the representation, combination and propagation of uncertainty, where this theory has several characteristics that are intuitively in accordance with the way of thinking of an expert, but have a strong mathematical basis.

To develop this research, the research uses the Tsukamoto fuzzy algorithm which is a method for classifying objects based on the most similar data and adds the Dempster Shafer algorithm as a comparison of the methods used to obtain maximum validation results.

II. RESEARCH METHODS

This study aims to develop and implement the Tsukamoto fuzzy algorithm and the Dempster Shafer to provide accurate results on the results and methods of controlling disease in rice plants.

A. *Identification of problems*

Many factors affect the incidence of pests on rice plants, one of which is environmental conditions or pests that attack. The limitations of farmers to analyze the symptoms of rice plant diseases make it an obstacle to providing appropriate treatment for the disease. The shortage of agricultural experts is one of the important factors in providing education regarding the symptoms and diseases that are susceptible to pests. With this, the author wants to create an application that can be accessed at any time by farmers and can always be updated regarding symptoms and diseases that attack rice plants in real time.

B. *Study of literature*

An expert system is an AI program with a knowledge base obtained from the experience or knowledge of an expert or expert in solving problems in a particular field and is supported by an Interference Engine/Inference Engine that performs reasoning or tracking of something or facts and rules that exist in the knowledge base after a search, so that conclusions are reached. (Liebowitz, 2017).

After carrying out the data collection method, the researchers thought about how to create an application that can be accessed in real time by agricultural experts and by farmers. Here experts can always add updated symptoms and diseases and farmers can analyze according to the symptoms that occur in their rice plants, then the system will provide ways of dealing with symptoms that appear on the rice plant. As support for making this expert system, the author will add 2 algorithms, namely fuzzy tsukamoto and demper shafer as accuracy.

C. *System planning*

1) Business Process Analysis

Currently, the business process carried out by farmers to get results from analyzing diseases or pests on their rice plants manually is by asking agricultural experts then the expert analyzes the rice plants and farmers get the results from the expert analysis. For more details, the current business process is described in Figure 1 below.

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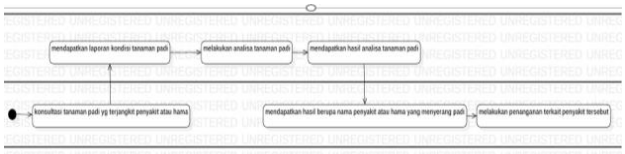

Fig. 1. Analysis of Current Business Process

Based on the current business process where farmers have to manually ask the expert system, and have to wait for the results of the analysis for a long time. For this reason, the proposed business process which can be seen in Figure 2, integrates a decision support system in a specially built application that will accurately produce disease results from inputs made by farmers.

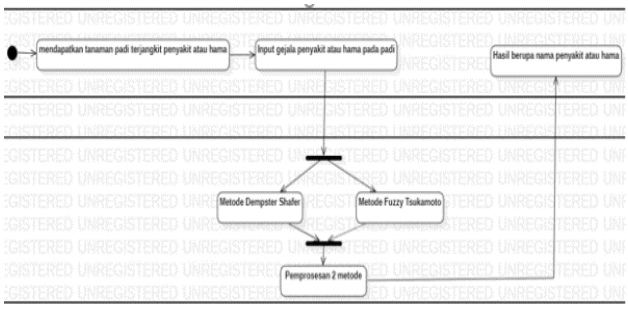

Fig. 2. Analysis of the Proposed Business Process

2) Use case diagrams

In the use case section, this diagram explains what will be done by the application to be built and who will interact with the application. Use case diagrams to become expert/farmer activities and expert systems. It can be seen in Figure 3.

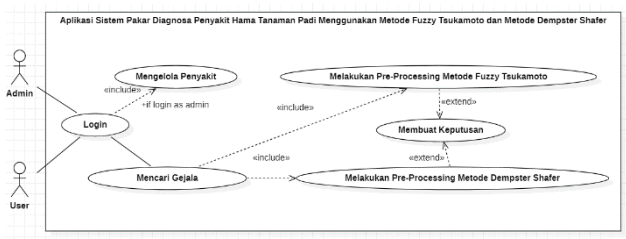

Fig. 3. Usecase Diagram

3) Sequence Diagrams

Here's Figure 4 which shows Sequence diagram to look for case similarities, where this sequence diagram explains the process flow to find similar cases, then equates the data with the disease data that has been inputted by the previous suer, then pre-processing with the Fuzzy Tsukamoto Method and the Dempster Shafer Method to get later results. make decisions based on previously entered data.

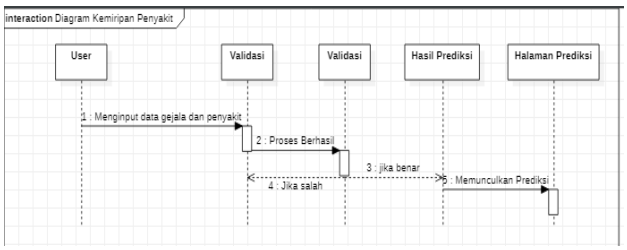

Fig. 4. Sequence Diagram Looking for Case Similarities

Sequence diagrams manage cases, namely the flow where, if the data has been inputted, it will give a decision according to the specified disease. Shown in Figure 5.

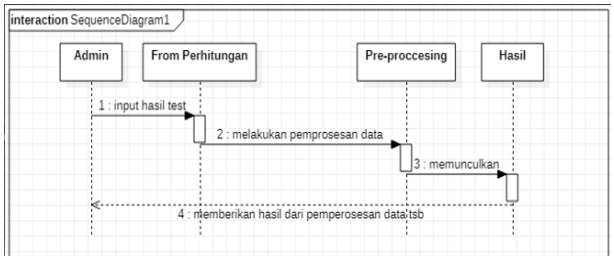

Fig. 5. Sequence Diagram of Managing Disease

4) Activity Diagrams

Activity Diagram illustrates the process of Admin/User inputting data to carry out plant disease cases, then calculating the weight, doing pre-processing using the Fuzzy Tsukamoto Method and the Dempster Shafer Method to get the results and then making decisions based on the data that has been inputted by the previous Admin / User displayed on Figure 6.

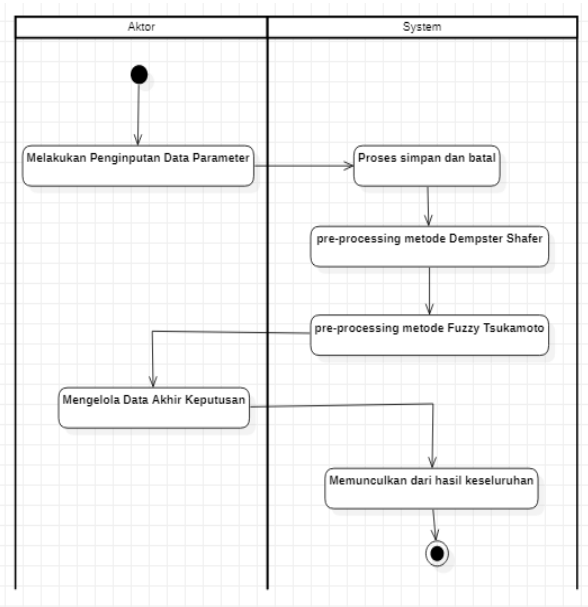

Fig. 6. Activity Diagram Looking for Symptoms Similarities

This Activity Diagram as in Figure 7 describes the process of Admin managing disease cases that have made a decision, based on the data that has been previously inputed.

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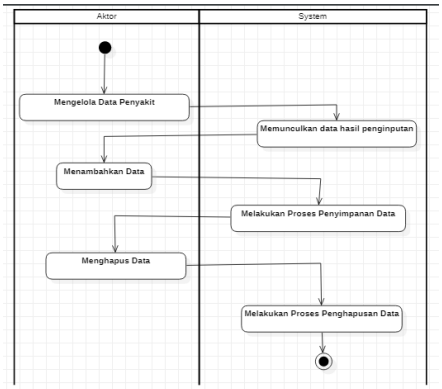

Fig. 7. Activity Diagram for Managing Disease Cases

5) Class Diagram

Class diagrams describe the structure of the system in terms of defining the classes created to build the system. Each class has its own attributes and methods. Classes that exist in the system must be able to perform functions according to system requirements. The class diagram of this forecasting application can be seen in Figure 8.

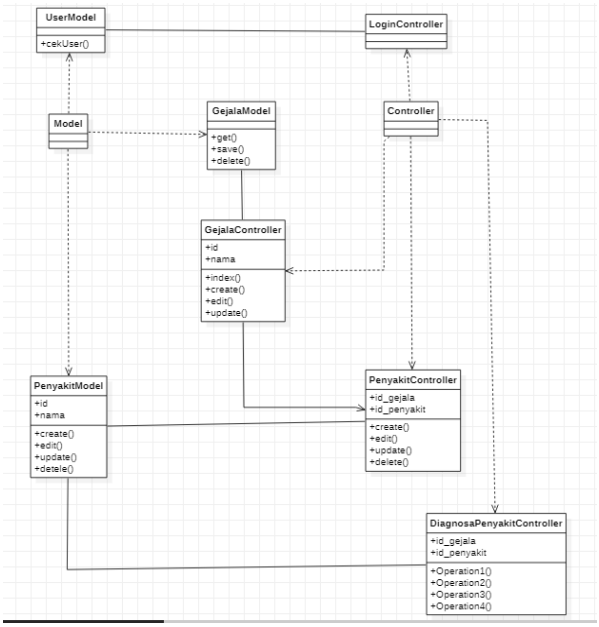

Fig. 8. Class Diagram

D. General Design

1) Interface Design

The interface is a description of the application to be developed can be seen on Figure 9. The purpose of interface design is to design an effective interface for the software system so that it can be understood by users and the results are according to needs.

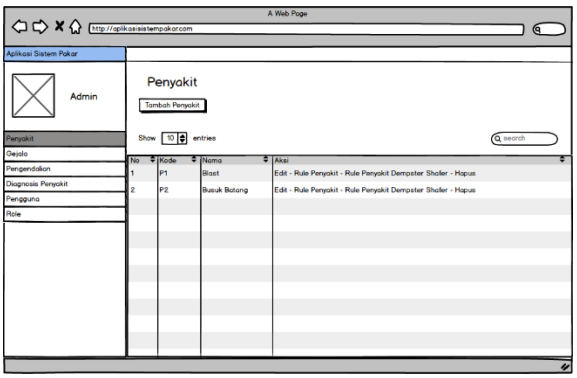

Fig. 9. Data Page Design

On the Data page menu above, there are several menus provided by the system, these menus are the criteria used in searching for a result. These criteria include tests that have been previously inputted. The criteria column will be filled in by the user according to the disease, which later the result of the search or the recommendation will be a diagnosis of disease in rice plants. Input Test Design interface can be seen at Figure 10 below.

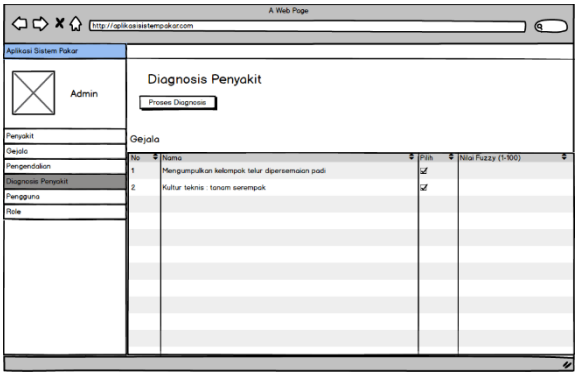

Fig. 10. Input Test Design

The input menu provided by the system for the user, where the function of this menu is to input the results of symptom and disease data.

2) Database Design

The first thing to do in building an expert system is to create a knowledge base structure. The knowledge base is a collection of facts. Some of the knowledge base structures in this expert system are as follows:

- Symptom knowledge base
- Disease knowledge base

In this case, a user can find out the type of disease and the value of his confidence level by entering the symptoms suffered by rice into the system so that the expert system with the Dempster Shafer Method and the Fuzzy Tsukamoto Method will match the symptoms entered with the type of disease that is present. on the basis of knowledge and also the system will provide a value for the certainty of the type of disease.

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The knowledge base contains the types of diseases, the symptoms of rice diseases can be seen in Table I.

TABLE I. Knowledge Base Symptoms of rice disease

No	Symptom Code	Name of Disease Symptom
1	G1	Symptoms of leaves yellow to orange
2	G2	Symptoms of reduced number of tillers
3	G3	Symptoms of dwarf plants
4	G4	Symptoms of oval-shaped spots / eclipse
5	G5	Symptoms of patches gradually enlarge
6	G6	Symptoms of stiff plant leaves
7	G7	Symptoms of dark brown spots
8	G8	Symptoms of spotting on the midrib
9	G9	Symptoms of white spots
10	G10	Symptoms of brown spots at the base of the neck
11	G11	Symptoms of dark brown spots
12	G12	Symptoms of dry leaves

In Table II below is a knowledge base containing all types of diseases that attack rice plants.

TABLE II. Rice Disease Knowledge Base

No	Disease Code	Rice Disease Name
1	P1	Bias (can attack leaves, stems, panicles and rice)
2	P2	Stem rot (Causes rice crop to be disturbed during early panicle filling)
3	P3	Bacterial Leaf Blight (causes decreased ability of plants to carry out photosynthesis and produce grain filling becomes less than perfect)
4	P4	Midrib blight (This disease is caused by white bacteria: Pseudomonas sp. and yellow: Bacillus sp)
5	P5	Tungro (tungro disease virus is transmitted from one plant to another) other plants by green leafhoppers or other leafhoppers)
6	P6	Grass Dwarf (this virus is caused by the brown planthopper. Virus stunted grass reduces crop yields by inhibiting panicle production)
7	P7	Weathered Dan (The development of this disease can be triggered development due to excessive fertilization)

*3) Interface Imple*mentation

Implementation of the interface (User Interface) is an application of the design that has been made previously. The following Figure 11 is the implementation of an expert system interface to diagnose rice pest symptoms using the Dempster Shafer and Fuzzy Tsukamoto algorithms.

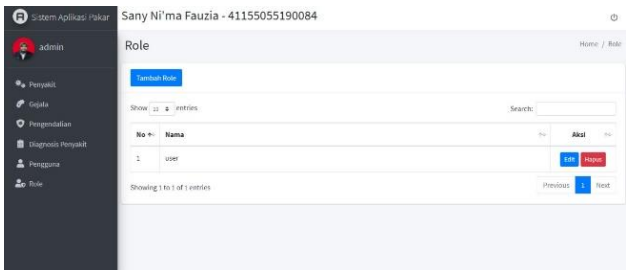

Fig. 11. Main Page

Figure 12 is the next page that can manage users to login, where there are several menus such as create, edit and delete.

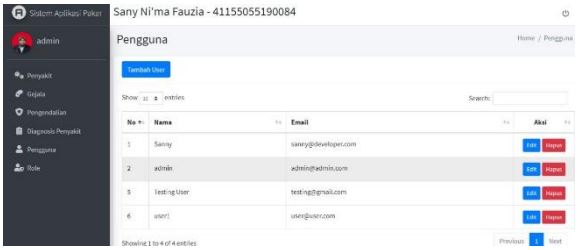

Fig. 12. User Page

Disease page as shown in Figure 13 is a page that can only be accessed by Admin / User who can later add, edit and delete disease data to be tested on Rice Plants.

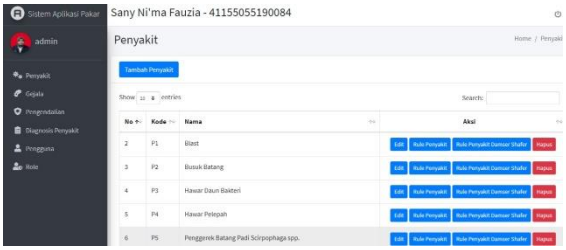

Fig. 13. Disease page

On this page shown in Figure 14, the user will be immediately presented with some symptVom data that was previously inputted, and can manage it such as adding, editing and deleting it.

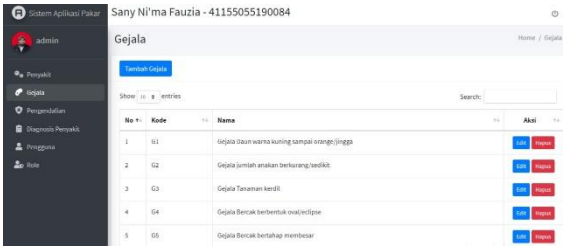

Fig. 14. Symptoms Page

4) Database Implementation

Implementation of this application database is based on the design that has been done. The implementation is shown from the screenshots contained on the database page, shown in Figures 15 to 18.

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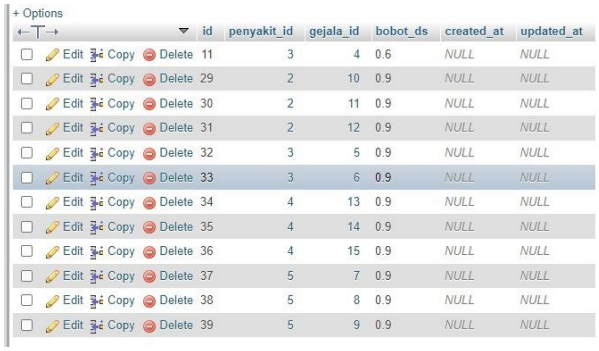
id	kode	nama	created_at	updated_at
1	G1	Gejala Daun warna kuning sampai orange/jingga	2020-10-18 05:02:51	2020-12-06 15:01:34
2	G2	Gejala jumlah anakan berkurang/sedikit	2020-10-18 14:15:46	2020-12-06 15:03:15
3	G3	Gejala Tanaman kerdil	2020-10-18 14:27:14	2020-12-06 15:09:43
4	G4	Gejala Bercak berbentuk oval/eclipse	2020-10-18 14:27:25	2020-12-06 15:24:16
5	G5	Gejala Bercak bertahap membesar	2020-10-18 14:27:40	2020-12-06 15:24:28
6	G6	Gejala daun tanaman kaku	2020-10-18 14:27:53	2020-12-06 15:30:20
7	G7	Gejala bercak coklat kehitaman	2020-10-18 14:28:15	2020-12-06 15:30:33
8	G8	Gejala bercak pada pelepah	2020-10-18 14:28:44	2020-12-06 15:30:45
9	G9	Gejala bercak warna putih	2020-10-18 14:28:53	2020-12-06 15:30:58
10	G10	Gejala bercak coklat pada pangkal leher	2020-10-18 14:29:16	2020-12-06 15:31:20
11	G11	Gejala bercak coklat kehitaman	2020-11-17 16:19:35	2020-12-06 15:31:34
12	G12	Gejala Daun mengering	2020-11-17 16:19:46	2020-12-06 15:31:48
13	G13	Gejala daun mengering	2020-11-17 16:20:13	2020-12-06 15:32:19
14	G14	Gejala daun melengkung dan melipat sepanjang ibu t...	2020-12-06 15:37:48	2020-12-06 15:37:48
15	G15	Gejala terdapat hawar pada daun	2020-12-06 15:38:03	2020-12-06 15:38:03
16	G16	Gejala Daun berwarna hijau pucat atau kuning pucat	2020-12-06 15:38:58	2020-12-06 15:38:58
17	G17	Gejala tidak membentuk malai/malai tidak keluar	2020-12-06 15:47:45	2020-12-06 15:47:45

Fig. 15. Implementation of Symptom Table Database

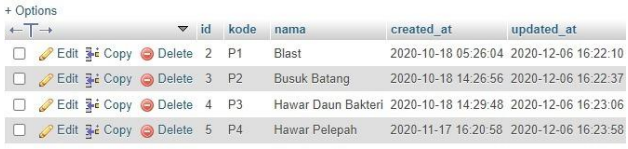


id	penyakit_id	gejala_id	bobot_ds	created_at	updated_at
11	3	4	0.6	NULL	NULL
29	2	10	0.9	NULL	NULL
30	2	11	0.9	NULL	NULL
31	2	12	0.9	NULL	NULL
32	3	5	0.9	NULL	NULL
33	3	6	0.9	NULL	NULL
34	4	13	0.9	NULL	NULL
35	4	14	0.9	NULL	NULL
36	4	15	0.9	NULL	NULL
37	5	7	0.9	NULL	NULL
38	5	8	0.9	NULL	NULL
39	5	9	0.9	NULL	NULL

Fig. 16. Implementation of the Disease Table Database

id	penyakit_id	rule	result	created_at	updated_at
1	2	[{"gejala_id":1,"value":"tinggi"},{"gejala_id":2,"...	ya	2020-10-20 01:13:20	2020-10-20 01:13:20
2	2	[{"gejala_id":1,"value":"tinggi"},{"gejala_id":2,"...	ya	2020-10-20 01:13:20	2020-10-20 01:13:20
3	2	[{"gejala_id":1,"value":"tinggi"},{"gejala_id":2,"...	ya	2020-10-20 01:13:20	2020-10-20 01:13:20
4	2	[{"gejala_id":1,"value":"tinggi"},{"gejala_id":2,"...	tidak	2020-10-20 01:13:20	2020-10-20 01:13:20
5	2	[{"gejala_id":1,"value":"rendah"},{"gejala_id":2,"...	tidak	2020-10-20 01:13:20	2020-10-20 01:13:20
6	2	[{"gejala_id":1,"value":"rendah"},{"gejala_id":2,"...	ya	2020-10-20 01:13:20	2020-10-20 01:13:20
7	2	[{"gejala_id":1,"value":"rendah"},{"gejala_id":2,"...	tidak	2020-10-20 01:13:20	2020-10-20 01:13:20
8	2	[{"gejala_id":1,"value":"rendah"},{"gejala_id":2,"...	tidak	2020-10-20 01:13:20	2020-10-20 01:13:20
9	3	[{"gejala_id":3,"value":"tinggi"},{"gejala_id":4,"...	ya	2020-10-20 01:14:57	2020-10-20 01:14:57
10	3	[{"gejala_id":3,"value":"tinggi"},{"gejala_id":4,"...	ya	2020-10-20 01:14:57	2020-10-20 01:14:57
11	3	[{"gejala_id":3,"value":"tinggi"},{"gejala_id":4,"...	ya	2020-10-20 01:14:57	2020-10-20 01:14:57
12	3	[{"gejala_id":3,"value":"tinggi"},{"gejala_id":4,"...	tidak	2020-10-20 01:14:57	2020-10-20 01:14:57
13	3	[{"gejala_id":3,"value":"rendah"},{"gejala_id":4,"...	tidak	2020-10-20 01:14:57	2020-10-20 01:14:57
14	3	[{"gejala_id":3,"value":"rendah"},{"gejala_id":4,"...	ya	2020-10-20 01:14:57	2020-10-20 01:14:57
15	3	[{"gejala_id":3,"value":"rendah"},{"gejala_id":4,"...	tidak	2020-10-20 01:14:57	2020-10-20 01:14:57

Fig. 17. Implementation of the Rule Disease Symptom Table Database



id	kode	nama	created_at	updated_at
2	P1	Blast	2020-10-18 05:26:04	2020-12-06 16:22:10
3	P2	Busuk Batang	2020-10-18 14:26:56	2020-12-06 16:22:37
4	P3	Hawar Daun Bakteri	2020-10-18 14:29:48	2020-12-06 16:23:06
5	P4	Hawar Pelepah	2020-11-17 16:20:58	2020-12-06 16:23:58

Fig. 18. Implementation of the Disease Data Table Database

III. TESTING AND DISCUSSION

A. Functional Testing

Functional testing is carried out to find out the location of errors or discrepancies that exist in the system that has been made. The tests that the researchers did were using black-box testing techniques. Black-box testing focuses on functional testing on the system being built. The results of the tests that have been carried out can be seen in the Table III below:

TABLE III. Functional Testing

No	Testing Description	Testing Skenario	Expected Result	Result	
				Success	Failed
1	Login	Fill in username and password correctly	The system provides login information successful and directed to the main menu User	V	
2	Testing User Login with wrong email and password	Wrong username and password	The system provides failed login information	V	
		Username is correct and password is wrong	The system provides failed login information	V	
		Wrong username and correct password	The system provides failed login information	V	
3	Test login User data empty	Fill in Username without password	The system provides failed login information	V	
		Fill in password without Username	The system provides failed login information	V	
		Not Filling Username and Password	The system provides failed login information	V	
4	Add disease data	Add disease data	The system has successfully added new disease data	V	
5	Edit disease data	Edit disease data	The system has successfully edited new disease data	V	
6	Delete disease data	Delete disease data	The system has successfully deleted new disease data	V	
7	Add symptom data	Add symptom data	The system has successfully added new symptom data	V	
8	Edit symptom data	Edit symptom data	The system has successfully edited new symptom data	V	
9	Delete symptom data	Delete symptom data	The system has successfully deleted new symptom data	V	

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B. Algorithm Testing

Belief can be formulated in the following equation :

$$Bel(x) = \sum_{y \leq x} (y) \qquad (1)$$

Plausibility (Pls) can be formulated in the following equation :

$$Pl(s) = 1 - Bel(s') = 1 - \sum_{y \leq x'} m(s') \qquad (2)$$

Where:
Bel(X) = Belief (X)
Pls(X) = Plausibility(X)
m(X) = mass function of (X)
m(Y) = mass function of (Y)
Plausibility is also worth 0 to 1, if you are sure of X' then it can be said Belief (X') = 1 so that from the formula the value of Pls (X) = 0. Several possible ranges between Belief and Plausibility can be seen in Table 3

TABLE III. Functional Testing

No	Possibility	Information
1	[1,1]	All Right All Wrong
2	[0,0]	Uncertainty
3	[0,1]	Tend to support Tend to
4	[Bel,1] where 0 < Bel < 1 [0,Pls]	Reject
5	Where 0 < Pls < 1 [Bel,Pls] where 0 <	Tend
6	Bel ≤ Pls < 1	Support and Reject

This theory is also known as the frame of discernment (FOD). which is denoted by. This FOD is a universe of talks from a set of hypotheses so that it is often called the environment (Adrian O'Neill, 2000), it can be formulated in the following equation :

$$\emptyset = \{\emptyset 1, \emptyset 2, \dots, \emptyset n\} \qquad (3)$$

Where :
$\emptyset$ = FOD or environment
1,… n = Elements/parts in environment

C. Calculation Algorithm

1) Case 1 (1 Symptom)

In this case, an example will be given by entering 1 symptom. For this calculation, suppose the user enters the symptoms of black spots on the leaf midrib.

Symptom 1: Black spots on the leaf midrib

Black spots were observed on the leaf midrib as a symptom of the disease with a value of m {P3} = 0.7, m {P4} = 0.4 for m1 the density value chosen was the highest, then:

m1 {P3} = 0.7
m1 {θ} = 1 – 0.7 = 0.3

From the calculation above, only one symptom is taken. So the results of the diagnosis can be concluded that the rice plant has stem rot disease.

2) Cases 2 (1 Symptom)

In this case, an example will be given by entering 2 symptoms. For this calculation, suppose the user enters the symptoms of black spots on the leaf midrib and the leaves change color to yellow/brown/gray.

Symptom 1: Black spots on the leaf midrib

Black spots were observed on the leaf midrib as a symptom of the disease with a value of m {P3} = 0.7, m {P4} = 0.4 for m1 the density value chosen was the highest, then:

m1 {P3} = 0.7
m1 { } = 1 – 0.7 = 0.3

Symptom 2: Leaves turn yellow/brown/grey

Then the addition of symptoms of leaves changing color to yellow/brown/gray, after observing these symptoms as symptoms of the disease with a density value of m{p5} = 0.7, m{p7} = 0.8 for m2 the density value chosen is the highest, so:

m2 {p5,p7} = 0.8
m2 {θ} = 1 – 0.8 = 0.2

Then the calculated new density values for several combinations with the density function m3 can be seen in Table 4 :

TABLE IV. Combination Rules For m3 case 2

m1	m2	
	{P5,P7} = 0,8	{Ø} = 0,2
{P3,P4} = 0,7	{Ø} = 0,56	{P3,P4} = 0,14
{Ø} = 0,3	{P5,P7} = 0,24	{Ø} = 0,06

So, it can be calculated by the following equation:

m3 {p5, p7} = 0.24/(1-0.56) = 0.54
m3 {p3, p4} = 0.14/(1-0.56) = 0.31
m3 { } = 0.06/(1-0.56) = 0.14

From the results of these calculations, the highest density value is 0.54 it can be concluded that the disease that attacks rice plants is probably Tungro disease.

IV. CLOSING

A. Conclusion

Research on an expert system for diagnosing rice pest disease symptoms using the Dempster Shafer and Fuzzy Tsukamoto algorithms, the conclusions are as follows:

The application of the Fuzzy Tsukamoto Method and the Dempster Shafer Method in an Expert System for Diagnosing Rice Pest Diseases starts from normalizing sample data and test data, where sample data is the amount of data provided by the application and test data is the amount of data inputted by the user, then it will be calculated by using Euclidean distance to determine the final value of the diagnosis of diseases in Rice Pest Plants.

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Based on the results of the implementation and testing conducted by researchers, it can be concluded that:

1) In this study, a test process was carried out on rice data, it was known that the Fuzzy Tsukamoto and Dempster Shafer algorithms could be used for an expert system for the diagnosis of rice plant pests.

2) It is known from the test results that the data has a value above 60%, thus the Dempster Shafer algorithm is very accurate and can be used in the Expert System for Diagnosing Rice Pest Diseases because it gives results in the form of numbers (percent) different from the results by the Fuzzy Tsukamoto algorithm only gives Yes or No results, with a value with a percentage accuracy of 100% divided according to the symptoms entered.

B. Suggestion

Research using the Fuzzy Tsukamoto Method and the Dempster Shafer Method has not yet entered the perfect stage and requires further development including:

1) Added new features and other functions to further enhance the previously created system.

2) Hopefully the next researcher can use more or better algorithms in getting maximum accuracy results.

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